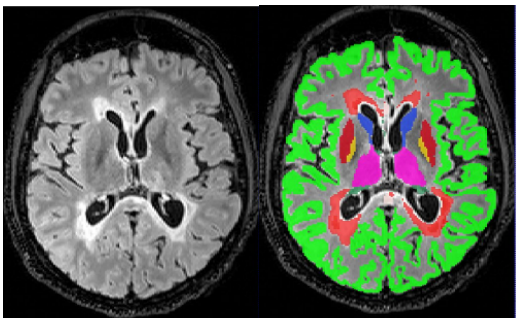


University Institute of Diagnostic and
Interventional Neuroradiology

Master's Thesis Proposal: Refilling MS lesions using CNNs

Multiple Sclerosis (MS) is an inflammatory and demyelating neurological disease that leads to white-matter (WM) lesions in brain and spinal cord and also to cerebral grey matter (GM) loss, which need to be monitored. **Brain morphometry** is a computational method that enables statistical assessment of brain structure based on T1-weighted magnetic resonance imaging (MRI) by extracting variables like local cortical thickness, surface area, gyrification indices and the contrast between grey and white matter along the cortical band. Originally developed for scientific group studies, variants are more and more utilized also to support clinical diagnostics in individual patients.

With the aim to minimize the compromise of WM lesions on the quantification of subcortical and cortical GM volumes, they are identified and usually refilled (Popescu et al., 2014) with normal WM intensities before applying brain morphometry toolboxes to patients with MS. Current software for the established practice of automated lesion refilling is unsatisfactory as lesion are usually filled with randomly sampled intensities resulting in unrealistic appearing tissue. Recently, we have developed a Deep Learning (DL) based algorithm for brain segmentation. **DeepSCAN** (McKinley et al., 2021) segments healthy brain structures and (if available) MS lesions at the same time. This helped to reduce the false positive rate considerably and led to accuracies similar to inter-rater agreement of human experts.

We propose to develop a DL-based **inpainting solution** to replace lesions with "normal" appearing brain. Starting point will be CNN-autoencoders or the U-Net (Ronneberger et al., 2016). If time allows, we will also explore the utility of generative adversarial networks (GAN). As training and test data we will use MRI of healthy subjects with synthetically introduced "lesions" as well as MRI of patients with MS where lesions were identified with DeepSCAN. In some patients MRI before and after appearance of new lesions will be available. In contrast to existing algorithms a DL-based algorithm will not be limited to sampling from the WM intensity distribution and have higher flexibility near or in the cortical band. Refilled MRI will then be evaluated with conventional software packages for brain morphometry and the impact of lesions will be assessed.

The student's tasks are:

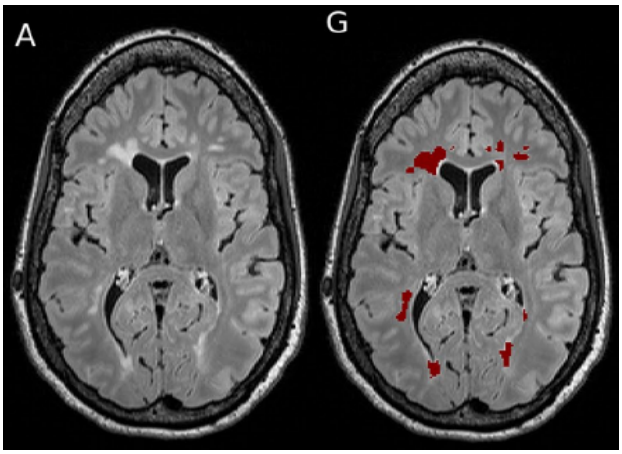
- review the literature on lesion refilling and DL
- curate training data
- devise and train DL-based lesion refiller
- evaluate performance

Specific requirements:

- programming skills in Python
- skills in data engineering
- basics in Deep Learning
- basic statistics

Nature of the master thesis:

- literature study: 10%
- data curation: 20%
- implementation: 20%
- data exploration: 30%
- documentation: 20%



Example of FLAIR-MRI of a patient with MS. On the left MS lesions were automatically identified using DeepSCAN.

References:

- McKinley R, Wepfer R, Aschwanden F, Grunder L, Muri R, Rummel C et al. (2021). Scientific Reports 11, 1087.
- Popescu V, Ran NCG, Barkhof F, Chard DT, Wheeler-Kingshott CA, Vrenken H (2014). NeuroImage Clinical 4, 366-373.
- Ronneberger O, Fischer P, Brox T (2016). arXiv:1505.04597.

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